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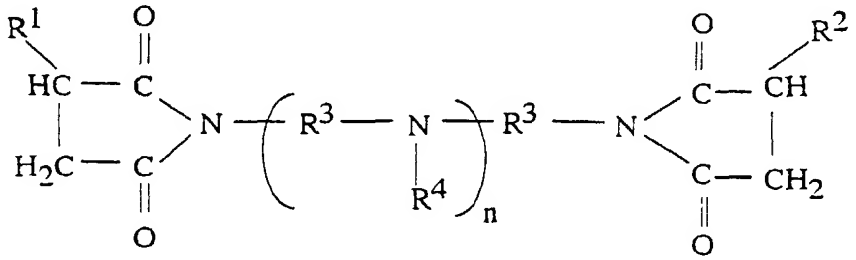
(54) LUBRICATING OIL COMPOSITION FOR AUTOMATIC TRANSMISSIONS

(57) The present invention relates to a lubricating oil composition for an automatic transmission obtainable by the addition to a base oil of: a compound represented by general formula (I),



(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 or more carbons; R^3 is a hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or amide bond; and n is an integer of 0 to 10);

0.02% by weight to 5% by weight of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates; and
at least one type selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters.

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The present invention also provides a method of lubricating an automatic transmission fitted with a continuously slipping torque converter clutch using said automatic transmission lubricating oil composition; and an automatic transmission filled with said automatic transmission lubricating oil composition.

A lubricating oil composition for an automatic transmission is used in an automobile automatic transmission provided with a continuously slipping torque converter clutch. It exhibits the remarkable effects of sufficient transmission torque capacity and high anti-shudder property even when the lock-up mechanism is operated at low speeds.

Description

Field of the Invention

The present invention relates to a lubricating oil composition for an automatic transmission. In more detail, it relates to a lubricating oil composition which has a high transmission torque capacity, exhibits excellent anti-shudder property, and is particularly suited for use in an automatic transmission provided with a continuously slipping torque converter clutch.

The present invention also provides a method for lubricating an automatic transmission provided with a continuously slipping torque converter clutch. It also provides an a automatic transmission filled with a lubricating oil composition which has a high transmission torque capacity and exhibits excellent anti-shudder property.

Background Art

An automatic transmission is constructed from a torque converter, a wet-type multi-plate clutch, gear wheel bearings and a hydraulic control mechanism for controlling these. It has a mechanism by which the transmission torque capacity is automatically set in accordance with the running conditions.

An automatic transmission fluid (ATF) is commonly used in these mechanisms inside this kind of automatic transmission. In order that the automatic transmission operates smoothly, it is required that the automatic transmission fluid functions as a drive transmission fluid, a lubricating oil and a hydraulic oil.

In recent years, the automatic transmissions of many automobiles have been equipped with a lock-up clutch inside the torque converter, which is effective in improving the fuel economy performance. It is designed to improve the efficiency of the torque converter by directly transmitting the drive of the engine to the transmission in accordance with the running conditions, by switching between torque converter drive and direct drive at appropriate times. Conventional lock-up mechanisms are only operated at high speeds and not at low speeds. This had the result that at low speeds, such as at the time of pulling away, there was a loss in drive transmission between the output revs of the engine and the input revs of the transmission when torque was transmitted by the torque converter, which caused a reduction in the fuel economy performance. In order to reduce this drive transmission loss and improve the fuel economy performance, slip control has been recently introduced which operates the lock-up clutch even at low speeds in the automatic transmission.

However, there has been the problem of abnormal car vibrations (called shudder) frequently occurring at the friction faces of the lock-up clutch when the lock-up clutch mechanism is operated at low speeds. In particular, with lock-up clutches in a continuously slipping torque converter, shudder tends to be generated when there is a reduction in the friction coefficient accompanying an increase in the slipping velocity. There is therefore a demand for an automatic transmission fluid composition whose μ (friction coefficient) - V (slipping velocity) characteristic is improved such that the friction coefficient increases with an increase in the slipping velocity, and which thereby exhibits excellent anti-shudder property.

Conventionally, phosphate esters, amides, carboxylic acids and amines etc. have been proposed as friction modifiers for use in automatic transmission fluids. However, these kind of friction modifiers have the problem that their capacity to transmit torque is not sufficient because they cause a reduction in the friction coefficient of the lock-up clutch. There has therefore been a demand for a lubricating oil for automatic transmissions which exhibits both anti-shudder property and transmission torque capacity, and there has been a strong desire for development of this technology.

Disclosure of the Invention

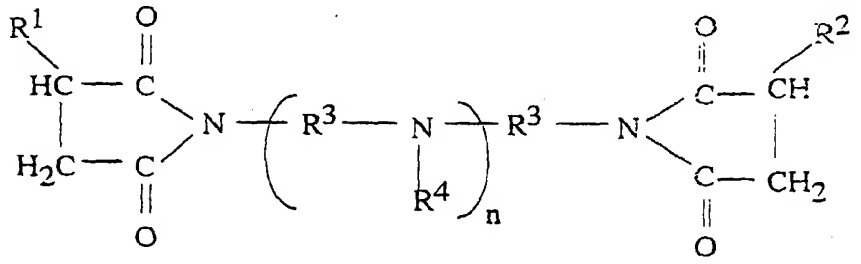
In light of the above-mentioned state of development of lubricating oils for automatic transmissions, the first objective of the present invention is to provide a lubricating oil composition for automatic transmissions which exhibits excellent anti-shudder property without any loss in transmission torque capacity.

The second objective of the present invention is to provide a method of lubricating an automatic transmission equipped with a continuously slipping torque converter clutch using a lubricating oil composition for an automatic transmission which has a high transmission torque capacity and exhibits excellent anti-shudder property.

The third objective of the present invention is to provide an automatic transmission filled with a lubricating oil composition having a high transmission torque capacity and exhibiting excellent anti-shudder property.

The inventors of the present invention conducted extensive research in order to achieve these objectives. They found as a result thereof that a lubricating oil composition obtained by incorporating a specific imide compound of the kind discussed below into a lubricating base oil sufficiently exhibited the kind of lubricating properties, transmission torque capacity and anti-shudder property required for lubricating oils for automatic transmissions, thereby achieving the specified objectives. It was on the basis of this finding that the present invention was completed.

The present invention relates to a lubricating oil composition for automatic transmissions obtainable by the addition to a lubricating base oil of an effective amount of a compound represented by the following general formula (1)

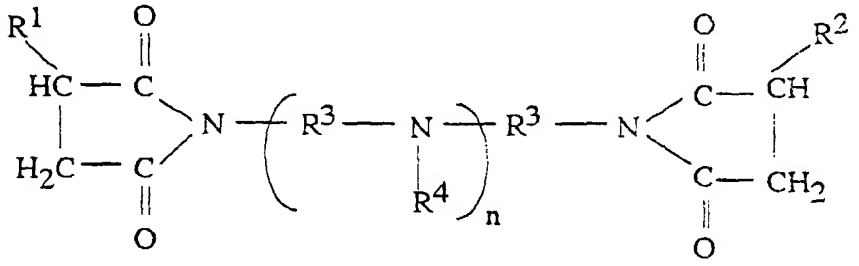


(I)

(wherein, in general formula (I), R^1 and R^2 may be identical or different from each other, and are each hydrocarbon groups having 5 or more carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons; and n is an integer in the range of 0 to 10).

Furthermore, according to the present invention, there is provided a lubricating oil composition for automatic transmissions obtainable by the addition to a lubricating base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (1)



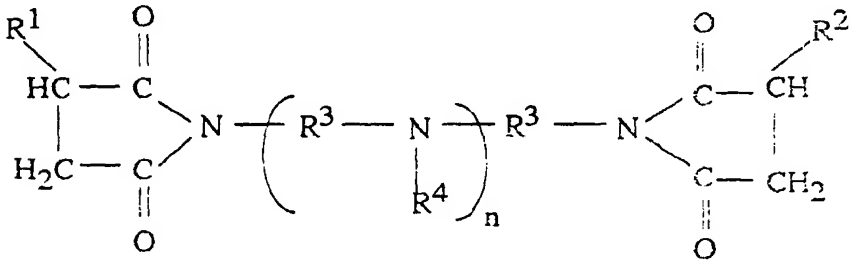
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 or more carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons; and n is an integer in the range of 0 to 10); and

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates.

Furthermore, according to the present invention, there is provided a lubricating oil composition for automatic transmissions obtainable by the addition to a lubricating base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 or more carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons; and n is an integer in the range of 0 to 10);

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates; and

(c) 0.01% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters.

Furthermore, according to the present invention, there is provided a method for lubricating an automatic transmission using a lubricating oil composition for automatic transmissions, which comprises a compound represented by the above general formula (I).

According to the present invention, there is also provided an automatic transmission filled with a lubricating oil composition for automatic transmissions, which comprises a compound represented by the above general formula (I).

The distinguishing feature of the present invention lies in the provision of a novel compound characterized in one sense in that the R^1 and R^2 groups of the imide compound represented by the above general formula (I) are straight chain hydrocarbon groups each having 5 or more carbons. It is focused on the finding that the anti-shudder property could be improved without reducing the transmission torque capacity of the lubricating oil for automatic transmissions, which are friction modifier effects which were not observed in the prior art.

Most Preferred Embodiment of the Invention

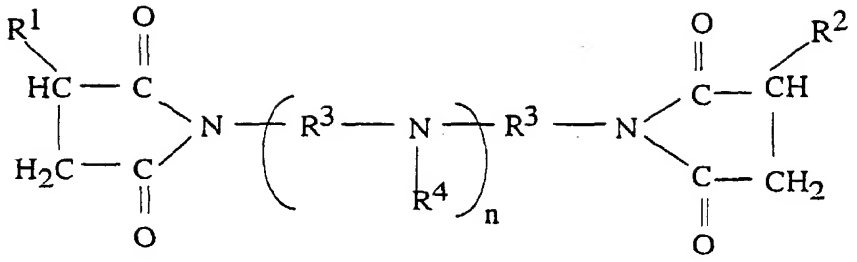
There are no particular restrictions regarding the base oil for the lubricating oil composition for an automatic transmission of the present invention. Any oil generally used as a lubricating base oil can be employed. Mineral or synthetic oils etc. can be used.

Mineral oils which can be used include: solvent-refined raffinates prepared by taking a lubricating oil feedstock obtained by atmospheric or vacuum distillation of crude oil and treating it with an aromatic extracting solvent such as phenol, furfural, N-methyl pyrrolidone; hydrogenated oils obtained by contacting a lubricating oil feedstock with hydrogen in the presence of a hydrogenation catalyst and under hydrogenation conditions; isomerized oils obtained by contacting wax with hydrogen in the presence of an isomerization catalyst and under isomerization conditions; or mixtures of these. Lubricating base oil blending stocks are normally produced by an arbitrary combination of steps such as solvent refining, hydrogenation, isomerization etc.. With any production method, a refining step such as dewaxing, hydrofinishing, activated clay treatment etc. can be arbitrarily employed. Specific examples of mineral base oil blending stocks include light neutral oil, medium neutral oil, and heavy neutral oil brightstock etc..

Examples of synthetic base oils include poly-alpha-olefins, alpha-olefin oligomers, polybutenes, alkyl benzenes, polyolesters, dibasic acid esters, polyoxyalkylene glycols, polyoxyalkylene glycol esters or polyoxyalkylene glycol ethers, and silicone oils etc..

The desired lubricating base oil can be produced by appropriate mixing of one or two or more types, for example two or more types of mineral oils or a mineral oil and a synthetic oil such that the base oil blending stocks meets the necessary quality requirements for automatic transmission lubricating oils such as kinematic viscosity. An oil having a kinematic viscosity at 100°C in the range of $2mm^2/s$ to $20mm^2/s$, preferably $3mm^2/s$ to $15mm^2/s$ can be used as the lubricating base oil of the present invention. If the viscosity of the base oil is too high, its low temperature viscosity properties are reduced. On the other hand, if its viscosity is too low, there is the risk of increased wear of sliding parts such as the clutch and the gear wheel bearings of the automatic transmission.

The imide compound used in the lubricating oil composition for an automatic transmission of the present invention is a compound represented by the following general formula (I)



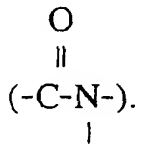
(I)

In the above general formula (I), R^1 and R^2 may be the same as each other or different from each other, and are each saturated or unsaturated hydrocarbon groups having 5 or more carbons, preferably 5 to 40 carbons. Examples of hydrocarbon groups include pentyl groups, hexyl groups, heptyl groups, octyl groups, nonyl groups, decyl groups, dodecyl groups, tridecyl groups, tetradecyl groups, pentadecyl groups, hexadecyl groups, heptadecyl groups, octadecyl groups, nonadecyl groups, oleyl groups and other hydrocarbon groups having up to 40 carbons. Preferred hydrocarbon groups include straight chain hydrocarbon groups having between 8 and 25 carbons. Hydrocarbon groups having 4 or less carbons would lower the anti-shudder property with the risk of not being able to provide a lubricating oil composition having sufficient practical value as an automatic transmission lubricating oil.

In the above general formula (I), R^3 is a divalent hydrocarbon group having 1 to 5 carbons, preferably an alkylene group having 2 or 3 carbons.

In the above general formula (I), R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons. Examples of hydrocarbon groups include alkyl groups having 1 to 20 carbons; alkenyl groups having 2 to 20 carbons; cycloalkyl groups having 6 to 20 carbons; and aryl groups having 6 to 20 carbons. The aryl groups may have an alkyl group having 1 to 12 carbons. Hydrogen atoms and alkyl groups having 1 to 10 carbons are particularly preferred as R^4. Groups having a number of (i.e. 1 to 5 of each) amino groups and/or amide bonds in their structure can be used as the above-described hydrocarbon groups.

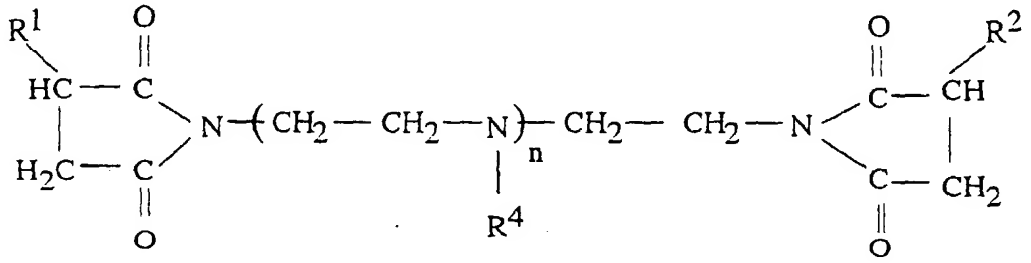
The amino groups are represented by -NH- or $-NH_2$; and the amide bonds are represented by



They may be bonded with the carbons of the hydrocarbon group at an arbitrary position.

In the above general formula (I), n is an integer between 1 to 10, preferably 1 to 5.

According to the present invention, a compound represented by the following general formula (II) is a particularly preferred specific example of the compound represented by the formula (I)



(II)

In the above formula (II), R^1 and R^2 are each straight chain hydrocarbon groups having 8 to 25 carbons; R^4 is a

hydrogen atom or a hydrocarbon group having 1 to 10 carbons, wherein said hydrocarbon group may have an amino group and/or an amide bond; and n is an integer between 1 and 5.

The imide compound of the present invention is added in an effective amount to the base oil of the lubricating oil composition for an automatic transmission. The amount of imide compound which is effective will vary depending on the components and properties of the base oil, but 0.02% by weight to 4% by weight, preferably 0.03% by weight to 3% by weight (based on the total weight of the lubricating oil composition) can be used.

The above-described imide compound can be synthesized by reacting a hydrocarbon-substituted succinic acid anhydride with a polyamine. Examples of polyamines preferred for this synthesis include monodiamines such as ethylene diamine, propylenediamine, butylenediamine, pentylenediamine etc.; and polyalkylenepolyamines such as diethylenetriamine, triethylenetetraamine, tetraethylenepentaamine etc..

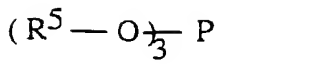
The incorporation of an imide compound represented by the above general formula (I) as an essential component in the lubricating oil composition for an automatic transmission of the present invention gives it improved shudder vibration performance without any reduction in the transmission torque capacity when it is used as an automatic transmission fluid. In particular, it is remarkably effective at preventing shudder vibration in automatic transmissions fitted with a continuously slipping torque converter clutch. Furthermore, the anti-shudder property can be improved one step further by the addition of a metal salt of an organic acid and/or a phosphorous compound in combination with the imide compound.

Examples of metal salts of organic acids include sulfonates, phenates, salicylates and phosphonates etc.. The metal component of the metal salt of the organic acid is preferably an alkaline earth metal such as calcium, magnesium, barium etc.. Specific examples of organic acid metal salts which can be used include calcium sulfonates, phenates, salicylates and phosphonates; magnesium sulfonates, phenates, salicylates and phosphonates etc.. The sulfonates, phenates, salicylates and phosphonates include hydrocarbon groups. It is preferred that at least one of the hydrocarbon groups is one having a relatively long chain of 6 or more carbons. Examples of groups which can be used include straight chain or branched alkyl groups having 6 to 18 carbons; straight chain or branched alkenyl groups having 6 to 18 carbons; cycloalkyl groups having 6 to 18 carbons; and aryl groups having 6 to 18 carbons. The aryl groups may include alkyl groups of 1 to 12 carbons or alkenyl groups of 2 to 12 carbons as substituents. Amongst the above-mentioned hydrocarbon groups, alkyl groups having 6 to 18 carbons are preferred. Alkyl groups having 8 to 12 carbons are particularly preferred from the point of view of improvement of the transmission torque capacity. Specific examples of sulfonates include alkylbenzene sulfonates such as hexylbenzene sulfonate, hexadecyltoluene sulfonate, hexadecylxylene sulfonate, octadecylbenzene sulfonate, dodecylbenzene sulfonate etc.. Calcium and magnesium are the preferred metal components. In the case of salicylates, ones having alkyl groups having 10 to 14 carbons are particularly preferred. A specific example is dodecyl salicylate. Calcium and magnesium are suitable metal components. Metal salts of alkylphenols or alkylphenol sulfides are the preferred phenates. Examples include calcium salts of dodecylphenol or alkylphenol sulfide. The phosphonates are metal salts of thiophosphonic acid or phosphonic acid obtainable by the reaction of a polyolefin and phosphorous pentasulfide; calcium and magnesium are used as the metal component. These organic acid metal salts are preferably ones having a total base value in the range of 10mgKOH/g to 400mgKOH/g.

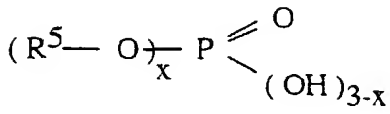
It is effective to include the metal salts of organic acids such as sulfonates, phenates, salicylates and phosphonates in an amount in the range of 0.02% by weight to 5% by weight, preferably 0.1% by weight to 2% by weight based on the total weight of the lubricating oil composition.

These metal salts of organic acids may be ones produced by conventional methods. It is also possible to select and use commercial products.

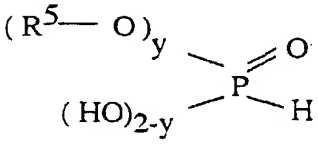
Examples of phosphorous compounds include phosphate esters, acid phosphate esters, phosphite esters, acid phosphite esters and zinc thiophosphates. Compounds represented by the general formulas (III), (IV) and (V) can be used.



(III)



(IV)



(V)

In these general formula (III) to (V), R^5 is a hydrocarbon group or a sulfur atom-containing hydrocarbon group having 1 to 30 carbons, and may be the same or different in each of the general formulae. x is 1, 2 or 3; y is 1 or 2. Preferred hydrocarbon groups are alkyl groups having 1 to 30 carbons; alkenyl groups having 2 to 30 carbons; cycloalkyl groups having 6 to 30 carbons; aryl groups, alkyl aryl groups and aryl alkyl groups having 6 to 30 carbons. Particularly suitable hydrocarbon groups are straight chain or branched alkyl groups having 3 to 24 carbons.

Specific examples of phosphate esters include triaryl phosphates such as benzyldiphenyl phosphate, aryldiphenyl phosphate, triphenyl phosphate, tricresyl phosphate, ethyldiphenyl phosphate, tributyl phosphate, dibutyl phosphate, cresyl diphenyl phosphate, dicresylphenyl phosphate, ethylphenyldiphenyl phosphate, diethylphenylphenyl phosphate, propylphenyldiphenyl phosphate, dipropylphenyl phenyl phosphate, triethylphenyl phosphate, tripropylphenyl phosphate, butylphenyldiphenyl phosphate, dibutylphenylphenyl phosphate, tributylphenyl phosphate, propylphenylphenyl phosphate mixtures and butylphenylphenyl phosphate mixtures. Of these compounds, phosphates having an alkyl group of 3 to 10 carbons are preferred.

Examples of acid phosphite esters include monobutyl phosphate, monohexyl phosphate, monooctyl phosphate, monolauryl phosphate, monophenyl phosphate, dibutyl phosphate, dioctyl phosphate, di(2-ethylhexyl) phosphate, didecyl phosphate, dilauryl phosphate, dioleyl phosphate, distearyl phosphate and diphenyl phosphate etc.. Of these compounds, monoalkyl or dialkyl phosphates having alkyl groups of 3 to 10 carbons or mixtures thereof are preferred.

Examples of phosphite esters include triphenyl phosphite, tri(p-cresyl) phosphite, tris(nonylphenyl) phosphite, trioctyl trithiophosphite, triisooctyl phosphite, diphenyl isodecyl phosphite, phenyl isodecyl phosphite, triisodecyl phosphite, tristearyl phosphite and trioleyl phosphite etc..

Examples of acid phosphite esters include di-2-ethylhexyl hydrogen phosphite, dilauryl hydrogen phosphite, and dioleyl hydrogen phosphite etc..

An example of a sulfur atom-containing hydrocarbon group is dodecyl thioethyl group etc..

The above phosphorous compound is added to the lubricating base oil in an amount of 0.01% by weight to 5% by weight, preferably 0.03% by weight to 3 % by weight based on the total weight of the lubricating oil composition. Amounts in the range of 0.05% by weight to 1% by weight are particularly preferred.

The above phosphorous compound may be one obtained by conventional production methods. Alternatively, a commercially available product may be selected and used.

Where necessary, other additives can be appropriately added to the lubricating oil composition for the automatic transmission of the present invention. Examples include other friction modifiers, anti-wear additives, viscosity index improvers, ashless dispersants, antioxidants, extreme pressure agents, metal deactivators, pour point depressants, defoamants and corrosion inhibitors.

Examples of viscosity index improvers include polymethacrylates, polyisobutylenes, ethylene-propylene copolymers and the product of hydrolytic copolymerization of styrene and butadiene etc.. These are used in an amount of 3% by weight to 35% by weight.

Examples of ashless dispersants include polybutenyl succinic acid imides, polybutenyl succinic acid imides, benzylamines, succinic acid esters etc.. These are used in an amount of 0.05% by weight to 7% by weight.

Examples of antioxidants include amine-type antioxidants such as alkylated diphenylamines and phenyl-alpha-

naphthyl amines etc.; phenol-type antioxidants such as 2,6-ditertiarybutyl phenol and 4,4'-methylenebis(2,6-ditertiarybutyl phenol) etc.; and zinc dithiophosphate etc.. These are used in an amount of 0.05% by weight to 5% by weight.

Examples of extreme pressure additives include dibenzyl sulphide and dibutyl disulfide etc.. These are used in an amount of 0.05% by weight to 3 % by weight.

Examples of metal deactivators include benzotriazole and thiadiazole etc.. These are used in an amount of 0.01% by weight to 3% by weight.

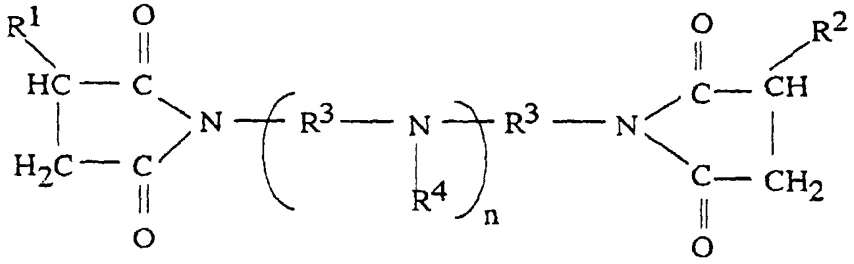
Examples of pour point depressants include ethylene-vinyl acetate copolymers, condensates of chlorinated paraffin and naphthalene, condensates of chlorinated paraffin and phenol, polymethacrylate and polyalkylstyrene etc.. These are used in an amount of 0.1% by weight to 10% by weight. Other additives such as anticorrosion inhibitors and defoamants can be used to the extent that they do not deter from the objective of the present invention.

The above-described types of additives and their amounts are compiled below.

	Amount (wt.%)	Preferred Amount (wt.%)
Viscosity index improver	3 - 35	4 - 30
Ashless dispersant	0.05 - 7	0.1 - 5
Antioxidant	0.05 - 5	0.1 - 3
Extreme pressure agent	0.05 - 3	0.1 - 2
Metal deactivator	0.01 - 3	0.01 - 2
Pour point depressant	0.1 - 10	0.5 - 8
Corrosion inhibitor		0.01 - 5
Defoamant		0.0001 - 1

Next, preferred embodiments (1) to (13) of the lubricating oil composition of the present invention will be described. There is provided:

(1) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricating base oil of an effective amount (on the basis of the total weight of the composition) of a compound represented by the general formula (I)

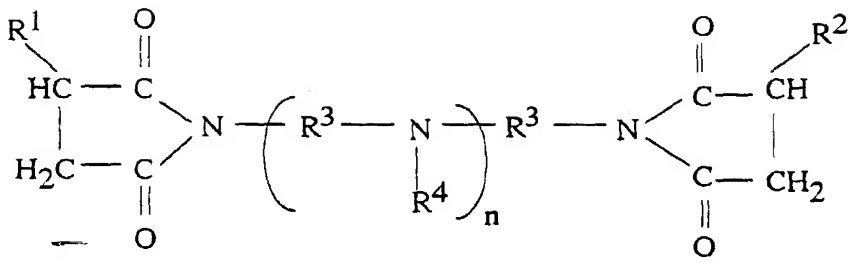


(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 to 40 carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 1 to 10).

(2) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



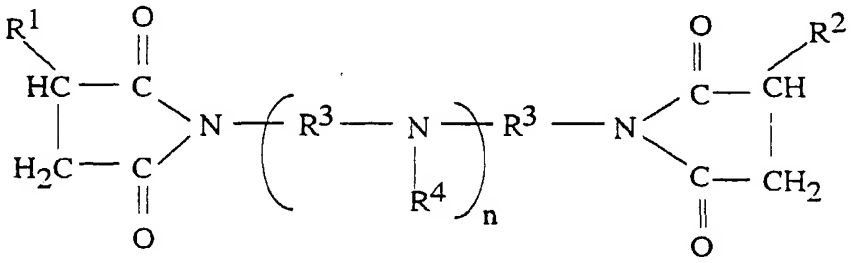
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 to 40 carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 1 to 5); and

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates.

(3) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricant base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



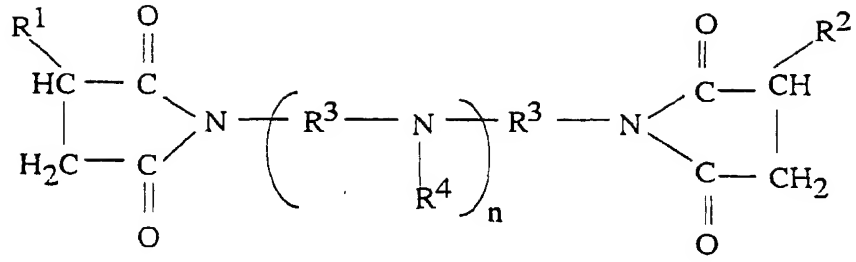
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 to 40 carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10);

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, phosphonates and salicylates; and

(c) 0.01% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters, and acid phosphite esters.

(4) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricating base oil of an effective amount of a compound represented by the general formula (I)

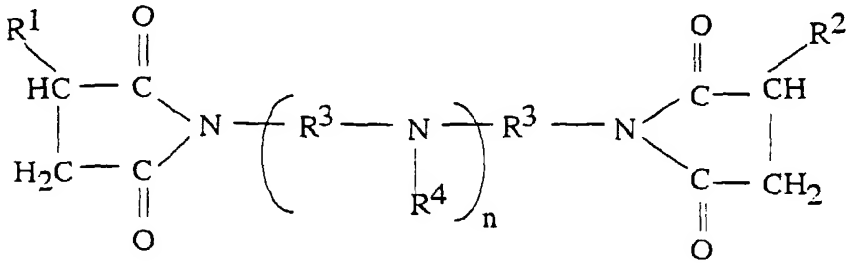


(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight chain hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10).

(5) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of:

(a) 0.02% by weight to 2% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



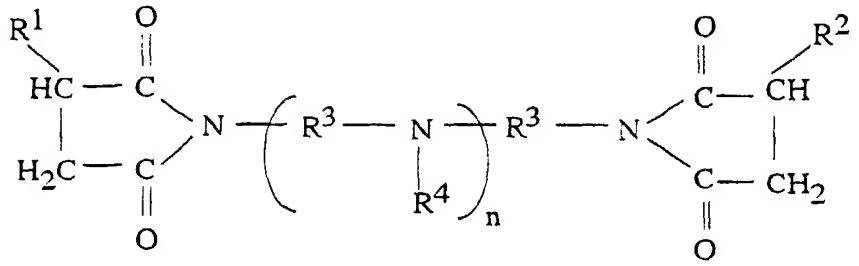
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10); and

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonate, phenates, salicylates and phosphonates.

(6) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricating base oil of:

(a) 0.02% by weight to 2% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



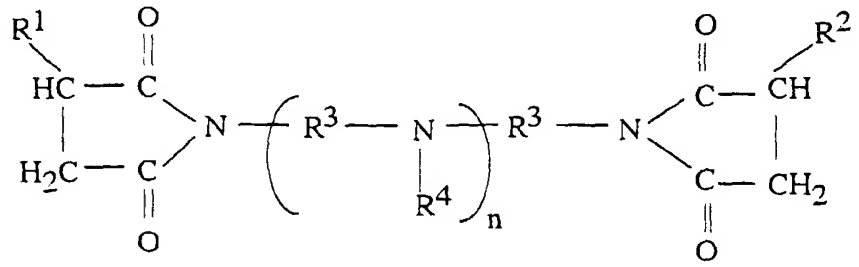
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10);

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates; and

(c) 0.01% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters.

(7) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of an effective amount of a compound represented by the general formula (I)

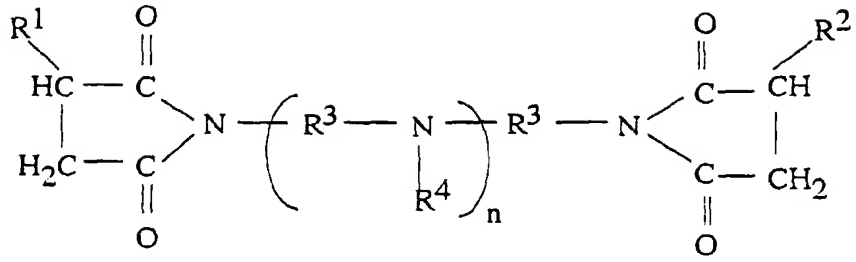


(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight chain unsaturated hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10).

(8) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of:

(a) 0.02% by weight to 2% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



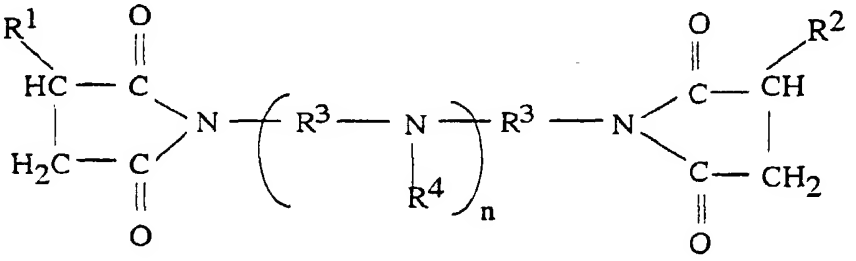
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain unsaturated hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10); and

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonate, phenates, salicylates and phosphonates.

(9) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricating base oil of:

(a) 0.02% by weight to 2% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (I)



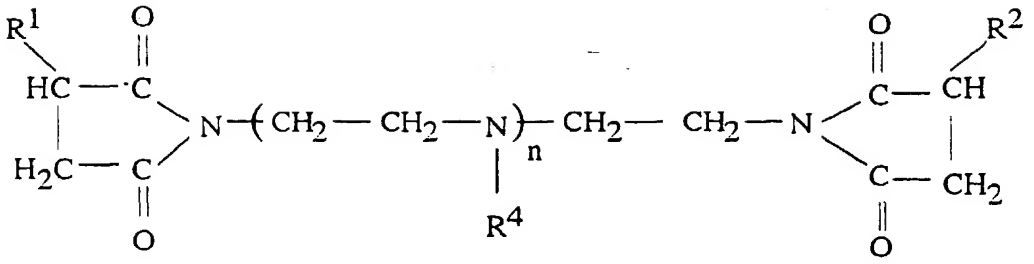
(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain unsaturated hydrocarbon groups having 8 to 25 carbons; R^3 is a divalent hydrocarbon group having 2 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 0 to 10);

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and hosphonates; and

(c) 0.01% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters.

(10) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of a compound represented by the general formula (II)

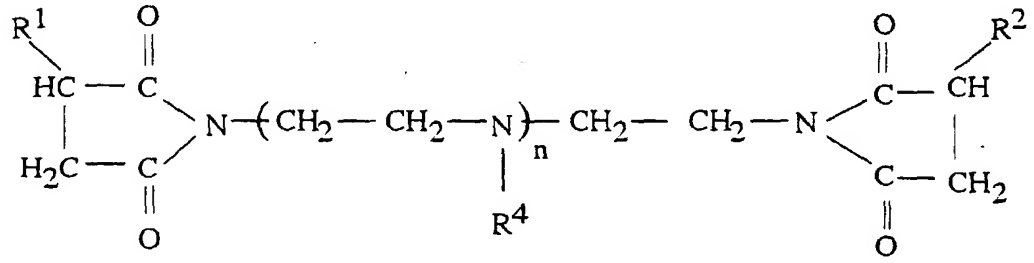


(II)

(wherein in general formula (II), R^1 and R^2 may be identical or different from each other and are each unbranched straight chain hydrocarbon groups having 8 to 25 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 10 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 1 to 5).

(11) A lubricating oil composition for an automatic transmission obtained by the addition to a lubricating base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (II)



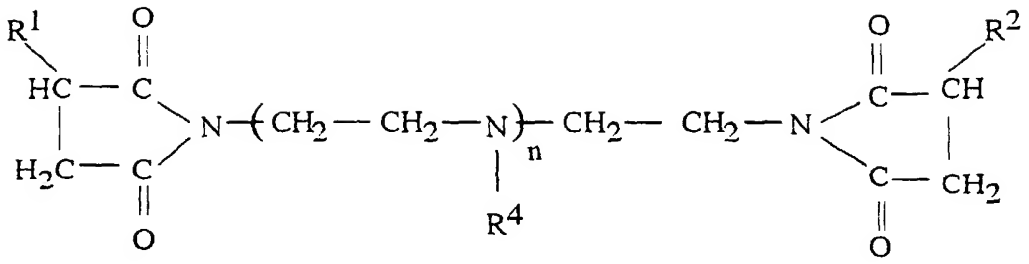
(II)

(wherein in general formula (II), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 10 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 1 to 5); and

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates.

(12) A lubricating oil composition for an automatic transmission obtainable by the addition to a lubricating base oil of:

(a) 0.02% by weight to 4% by weight (based on the total weight of the lubricating oil composition) of a compound represented by general formula (II)



(II)

(wherein in general formula (II), R^1 and R^2 may be identical or different from each other and are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 10 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer in the range of 1 to 5);

(b) 0.02% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates; and

(c) 0.01% by weight to 5% by weight (based on the total weight of the lubricating oil composition) of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters.

or

(13) A lubricating oil composition for an automatic transmission obtained by the addition to said lubricating base oil of a compound represented by the above general formula (I); said metal salt of an organic acid and/or said phosphorous compound; and at least one type of additive selected from the group consisting of antiwear additives, viscosity index improvers, ashless dispersants, antioxidants, metal deactivators, corrosion inhibitors, defoamants and other additives required for automatic transmission lubricating oil compositions.

Specifically, there is provided a lubricating oil composition for an automatic transmission obtained by the addition to a solvent-refined paraffinic mineral oil having a kinematic viscosity at 100°C of 4mm^2/s as the lubricating base oil of:

imide compound (compound A)	0.5 - 2 wt.%;
metal salt of organic acid (calcium sulfonate)	0.1 - 0.5 wt. %;
phosphorous compound (trialkyl phosphate)	0.1 - 0.5 wt.%;
polymethacrylate	2 - 10 wt.%;
polybutenyl succinic imide	2 - 5 wt.%;
2,6-di-t-butyl-4-methyl phenol	0.2 - 1wt.%; and
benzotriazole	0.02 - 0.1 wt.%
based on the total weight of the lubricating oil composition.	

[Examples]

Hereunder, the present invention shall be explained in more detail with reference to Examples and Comparative Examples. However, the scope of the present invention is not to be limited by these examples.

Anti-shudder property and transmission torque capacity were evaluated according to the following methods.

(1) Anti-shudder property

A LVFA (Low Velocity Friction Apparatus) was used as the test apparatus.
The μ_H and μ_L were measured under the following test conditions, and the μ_H/μ_L, ratio was calculated therefrom.

Test Conditions

Friction Material:	SD-1777
Amount of Oil:	100cc
Oil Temperature:	80°C
Face pressure:	10kgf/cm^2

μ_H Friction coefficient at a relative slipping velocity of 1.5m/s
μ_L Friction coefficient at a relative slipping velocity of 0.5m/s

The μ_H/μ_L ratio was adopted as a anti-shudder property index and used as the basis for evaluating the shudder vibration prevention effect. If the μ_H/μ_L ratio (anti-shudder property index) is greater than 1, no shudders are generated in an actual automatic transmission.

(2) Transmission torque capacity

A SAE No. 2 Friction Test Apparatus was used as the test apparatus. A dynamic test and a static test were carried out under the following conditions.

Friction Material:	SD-1777, 3 pieces
Amount of Oil:	800cc
Oil Temperature:	100°C
Surface Pressure:	8kgf/cm^2

[Dynamic Test]

The friction material was rotated under no load at a speed of 3600rpm and an inertial weight of 3.5kgf.cm.s^2. Pressure was applied by sandwiching the friction material between steel plates to stop the rotation.

[Static Test]

Pressure was applied to the friction material by sandwiching it between steel plates. The friction material was then rotated at a speed of 0.72 rpm, and the rotational torque generated at that time was read and converted into a friction coefficient. The static friction coefficient, μs at the time of maximum torque when the friction material starts to slip at low speed rotation was measured.

The transmission torque capacity was evaluated using the static friction coefficient, μs in a SAE No. 2 test 100c/c. The transmission torque capacity was evaluated to be higher the greater the μs exceeded 0.100.

The composition of the imide compounds of the present invention (Compounds A-H) and the imide compounds used in the Comparative Examples (Compounds I-J) are compiled in Table 1. The composition of the lubricating base oils and additives used in Examples and Comparative Examples, and the performance evaluation of the lubricating oil compositions are compiled in Tables 2 to 4.

Example 1

A solvent-refined paraffinic mineral oil (kinematic viscosity at 100°C: 4mm^2/s) was used as the lubricating base oil. A lubricating oil composition containing 1.0% by weight of an imide compound (compound A), 0.3% by weight of calcium sulfonate (total base value: 300mgKOH/g), 0.2% by weight of tributyl phosphate, 5.0% by weight of polymethacrylate (viscosity index improver), 4.0% by weight of polyisobutenyl succinic imide (ashless dispersant), 0.4% by weight of 2,6-di-t-butyl-4-methylphenol (antioxidant) and 0.05% by weight of benzotriazole (metal deactivator) was prepared. Compound A used here is, as is shown in Table 1, a imide compound in which R^1 and R^2 are each straight chain alkyl groups having 12 carbons, R^3 is an alkylene group having 2 carbons, R^4 is a hydrogen atom and n is 2. The anti-shudder property and transmission torque capacity of the lubricating oil composition were measured with the following results.

- Anti-shudder property Index (μ_H/μ_L ratio in LVFA): 1.06
- Transmission torque capacity (Static friction coefficient μs in SAE No. 2 test 100c/c): 0.146

According to these results, it is clear from the fact that the anti-shudder property index of 1.06 was greater than 1.00 and the transmission torque capacity of 0.146 was greater than 0.100, that the drive transmission performance of the lubricating oil composition is excellent.

Example 2

A lubricating oil composition was prepared in the same way as Example 1 except that an alpha-olefin copolymeric synthetic oil (Kinematic viscosity at 100°C: 4mm^2/s [SHF41 provided by Mobil Sekiyu Kabushiki Kaisha]) was used instead as the lubricating base oil instead of the solvent-refined paraffinic mineral oil. The anti-shudder property index and transmission torque capacity were measured, and the results thereof are shown in Table 1. Substantially the same results as with the mineral base oil were achieved.

Examples 3-9

Lubricating oil compositions were prepared by the addition to the base oils shown in Table 1 of compound A and various additives in the amounts also shown in Table 1. In particular, tributyl phosphate (Example 3), tricresyl phosphate (Example 4), trioctyl trithiophosphite (Example 5), and a mixture (1:1) of monooctyl phosphate and dioctyl phosphate (Example 6) were used as the phosphorous compound. The anti-shudder property and the transmission torque capacity were determined for each lubricating oil composition prepared and the results are shown in Table 1.

Example 10

A lubricating oil composition was prepared in the same way as in Example 1 except that compound B shown in Table 1 was used instead of compound A as the imide compound. Compound B is an imide compound in which R^1 and R^2 are each straight chain alkyl groups having 12 carbons, R^3 is an ethylene group, R^4 is an alkyl group having 6 carbons, and which is bonded to 2-NH- groups and 1 -NH_2 groups. n is 2. The performance of the lubricating oil composition was evaluated and the results thereof are shown in Table 3. The anti-shudder property index (μ_H/μ_L ratio in LVFA) was 1.07 and the transmission torque capacity (Static friction coefficient μs in SAE No. 2 test 100c/c) was 0.146. Extremely excellent results were thus obtained.

Example 11

A lubricating oil composition was prepared according to the same conditions and operations as in Example 1 except that compound C was used instead of compound A as the imide compound. As shown in Table 1, compound C is an imide compound in which R^1 and R^2 are each straight chain alkyl groups having 18 carbons, R^3 is an ethylene group, R^4 is a hydrogen atom and n is 2. The results of the measurement of the anti-shudder property index (μ_H/μ_L ratio) and the transmission torque capacity (μs) of the lubricating oil composition are shown in Table 3.

Examples 12-14

Lubricating oil compositions were prepared in the same way as Example 1 except that compound D (Example 12), Compound E (Example 13) and Compound F (Example 14) were respectively used as the imide compound instead of compound A.

As shown in Table 1, Compound D is an imide compound in which R^1 and R^2 are each straight chain alkyl groups having 18 carbons, R^3 is an ethylene group, R^4 is an alkyl group having 8 carbons and including 2 amide bonds

and one amino group (-NH-), and n is 2.

Compound E is an imide compound in which R^1 and R^2 are each straight chain alkyl groups having 24 carbons, R^3 is an ethylene group, R^4 is a hydrogen atom and n is 2.

Compound F is an imide compound in which R^1 and R^2 are each straight chain alkyl groups having 8 carbons, R^3 is an ethylene group, R^4 is a hydrogen atom and n is 2.

Examples 15-16

Lubricating oil compositions were prepared in the same way as Example 1 except that compound G (Example 15) and Compound H (Example 16) were respectively used as the imide compound instead of compound A.

As shown in Table 1, Compounds G and H are imide compounds in which R^1 and R^2 each include straight chain unsaturated alkyl groups. The results of the evaluation are shown in Table 3.

Examples 17-19

Lubricating oil compositions were prepared using compound G as the imide compound and using acid phosphate esters and acid phosphite esters in the amounts shown in Table 3 instead of a phosphate ester. The compositions and results of the performance evaluation (anti-shudder property and transmission torque capacity) are shown in Table 3.

Comparative Examples 1-14

Lubricating oil compositions were prepared by mixing the base oils and additives shown in Table 4 in the proportions shown in the same table. The anti-shudder property index μ_H/μ_L ratio and the transmission torque capacity were determined for each composition and the results are shown in Table 4.

Compound I used in Comparative Example 12 is an imide compound in which R^1 and R^2 are each n-butyl groups having 4 carbons, R^3 is an ethylene group, R^4 is a hydrogen atom and n is 2.

Compound J used in Comparative Example 14 is an imide compound having a hydrocarbon group which is not a straight chain saturated hydrocarbon group; R^1 is a straight chain alkyl group having 12 carbons whereas R^2 is a cyclic hydrocarbon group.

The above-described Examples and Comparative Examples show that both a satisfactory anti-shudder property and transmission torque capacity can be achieved through the use of the novel imide compounds of the present invention. In Comparative Example 12, Compound I is used as an imide compound, but R^1 and R^2 thereof are each n-butyl groups having 4 carbons, and thus differ from the hydrocarbon groups of the present invention which have 5 or more carbons. In Comparative Example 13, 6% by weight of polyisobutenyl succinic imide (bis-type), which is 2% by weight more than in the other Examples and Comparative Examples, was added as an ashless dispersant. The polyisobutenyl group of the polyisobutenyl succinic imide used here is different from the non-branched straight chain hydrocarbon groups having 5 or more carbons used in the present invention, with the result that no improvement in the anti-shudder property was observed.

The anti-shudder property index of the lubricating oil composition of Comparative Example 14, which was prepared using compound J, was 0.94 which is less than 1.00, showing a poor anti-shudder property. Compound J has a cyclic compound as R^2, and this shows that anti-shudder property cannot be achieved whilst maintaining transmission torque capacity if both R^1 and R^2 are not straight chain hydrocarbon groups.

As shown in the Table, the R^1 and R^2 of Compounds A to H are straight chain alkyl groups having 8 or more carbons, and lubricating oil compositions made using these are remarkably effective with respect to anti-shudder property without any loss in transmission torque capacity.

As is clear from Comparative Examples 8 and 9, the use of the imide compounds of the present invention in certain ranges of amounts results in even more remarkable effects.

TABLE 1

Imide Compound \ Hydrocarbyl group	R^1		R^2		R^3	R^4				n
	Type	No. of Carbons	Type	No. of Carbons	No. of Carbons	No. of Carbons	No. of CO-N<	No. of -NH-	No. of $-NH_2$	
Compound A	Straight-chain Saturated	12	Straight-chain Saturated	12	2	0 (H atom)				2
Compound B	Straight-chain Saturated	12	Straight-chain Saturated	12	2	6		2	1	2
Compound C	Straight-chain Saturated	18	Straight-chain Saturated	18	1	0 (H atom)				2
Compound D	Straight-chain Saturated	18	Straight-chain Saturated	18	1	8	2	1		2
Compound E	Straight-chain Saturated	24	Straight-chain Saturated	24	2	0 (H atom)				2
Compound F	Straight-chain Saturated	8	Straight-chain Saturated	8	2	0 (H atom)				2
Compound G	Straight-chain Unsaturated	18	Straight-chain Unsaturated	18	2	0 (H atom)				1
Compound H	Straight-chain Unsaturated	18	Straight-chain Unsaturated	18	2	8	2	1		1
Compound I	Straight-chain Saturated	4	Straight-chain Saturated	4	2	0 (H atom)				2
Compound J	Straight-chain Saturated	12	Cyclic	12	2	0 (H atom)				2

*Compounds A to H are new imide friction modifiers according to the present invention; compounds I and J are compounds raised for comparison.

TABEL 2

			Examples								
			1	2	3	4	5	6	7	8	9
Base oil Comp.	Solvent-refined paraffinic mineral oil ($4mm^2/s$@100℃)		89.05		89.05	89.05	89.05	89.05	89.05	90.02	87.05
	Synthetic base oil (alpha-olefin copolymer, $4mm^2/s$@100℃)			89.05							
Additive Comp. Wt.%	Compound A		1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.03	3.0
	Compound B										
	Compound C										
	Compound D										
	Compound E										
	Compound F										
	Compound G										
	Compound H										
	Compound I										
	Compound J										
	Oleyl amide										
	Stearic acid										
	Calcium sulfonate		0.3	0.3	0.3	0.3	0.3	0.3		0.3	0.3
	Magnesium phenate								0.3		
	Tributyl phosphate		0.2	0.2	0.2				0.2	0.2	0.2
	Tricresyl phosphate					0.2					
	Monobutyl phosphate										
	Dibutyl phosphate										
	Monooleyl phosphate										
	Dioleyl phosphate										
	2-ethylhexyl hydrogen phosphite										
	Di-2-ethylhexyl hydrogen phosphite										
	Trioctyl trithiophosphite						0.2				
	1:1 mixture of monooctyl phosphate and dioctyl phosphate							0.2			
	Viscosity Index Improver	Polymethacrylate (Mw≒ 50000)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Ashless dispersant	Polyisobutenyl succinic imide (bis type)	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
		Polyisobutenyl succinic imide (mono type)			4.0						
	Metal Deactivator	Benzotriazole	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Antioxidant	2,6-di-t-butyl-4-methyl phenol	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
		Alkyl diphenyl amine									
Perform. Eval.	Shudder vibration prevention performance, μ_H/μ_L ratio in LVFA		1.06	1.04	1.08	1.06	1.12	1.05	1.06	1.02	1.12
	Torque transmission capacity, μs in SAE No.2 100c/c		0.146	0.148	0.143	0.147	0.141	0.145	0.146	0.148	0.135

*The additive contents are expressed as weight percentages based on the total weight of the composition.

TABEL 3

		Examples									
		10	11	12	13	14	15	16	17	18	19
Base oil Comp.	Solvent-refined paraffinic mineral oil (4mm²/s@100℃)	89.05	89.05	89.05	89.05	89.05	89.05	89.05	88.15	88.15	88.15
	Synthetic base oil (alpha-olefin copolymer, 4mm²/s@100℃)										
Additive Comp. Wt.%	Compound A										
	Compound B	1.0									
	Compound C		1.0								
	Compound D			1.0							
	Compound E				1.0						
	Compound F					1.0					
	Compound G						1.0		2.0	2.0	2.0
	Compound H							1.0			
	Compound I										
	Compound J										
	Oleyl amide										
	Stearic acid										
	Calcium sulfonate	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1
	Magnesium phenate										
	Tributyl phosphate	0.2	0.2	0.2	0.2	0.2	0.2	0.2			
	Tricresyl phosphate										
	Monobutyl phosphate								0.1	0.05	
	Dibutyl phosphate									0.05	
	Monooleyl phosphate								0.1	0.05	0.3
	Dioleyl phosphate									0.05	
	2-ethylhexyl hydrogen phosphite								0.1	0.05	
	Di-2-ethylhexyl hydrogen phosphite									0.05	
	Trioctyl trithiophosphite										
	1:1 mixture of monooctyl phosphate and dioctyl phosphate										
	Viscosity Index Improver: Polymethacrylate (Mw≒ 50000)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Ashless dispersant: Polyisobutenyl succinic imide (bis type)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Ashless dispersant: Polyisobutenyl succinic imide (mono type)										
	Metal Deactivator: Benzotriazole	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Antioxidant: 2,6-di-t-butyl-4-methyl phenol	0.4	0.4	0.4	0.4	0.4	0.4	0.4			
	Antioxidant: Alkyl diphenyl amine								0.4	0.4	0.4
Perform. Eval.	Shudder vibration prevention performance, μ_s/μ_L ratio in LVFA	1.07	1.07	1.05	1.06	1.02	1.12	1.09	1.03	1.02	1.05
	Torque transmission capacity, μs in SAE No.2 100c/c	0.146	0.147	0.145	0.145	0.140	0.152	0.149	0.131	0.132	0.127

*The additive contents are expressed as weight percentages based on the total weight of the composition.

TABEL 4

			Comparative Examples													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Base oil Comp.	Solvent-refined paraffinic mineral oil (4mm²/s@100℃)		90.05		90.05	90.05	90.05	90.05	90.05	90.04	85.05	89.75	89.75	89.05	88.05	89.05
	Synthetic base oil (alpha-olefin copolymer, 4mm²/s@100℃)			90.05												
Additive Comp. Wt.%	Compound A									0.01	5.0					
	Compound B															
	Compound C															
	Compound D															
	Compound E															
	Compound F															
	Compound G															
	Compound H															
	Compound I													1.0		
	Compound J															1.0
	Oleyl amide											0.3				
	Stearic acid												0.3			
	Calcium sulfonate		0.3	0.3	0.3	0.3	0.3	0.3		0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Magnesium phenate								0.3							
	Tributyl phosphate		0.2	0.2	0.2				0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Tricresyl phosphate					0.2										
	Monobutyl phosphate															
	Dibutyl phosphate															
	Monooleyl phosphate															
	Dioleyl phosphate															
	2-ethylhexyl hydrogen phosphite															
	Di-2-ethylhexyl hydrogen phosphite															
	Trioctyl trithiophosphite						0.2									
	1:1 mixture of monooctyl phosphate and dioctyl phosphate							0.2								
	Viscosity Index Improver	Polymethacrylate (Mw= 50000)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Ashless dispersant	Polyisobutenyl succinic imide (bis type)	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	6.0	4.0
		Polyisobutenyl succinic imide (mono type)			4.0											
	Metal Deactivator	Benzotriazole	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Antioxidant	2,6-di-t-butyl-4-methyl phenol	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
		Alkyl diphenyl amine														
Perform. Eval.	Shudder vibration prevention performance, μ_H/μ_L ratio in LVFA		0.92	0.91	0.95	0.93	0.97	0.92	0.90	0.97	1.14	1.00	1.04	0.93	0.95	0.94
	Torque transmission capacity, μ_S in SAE No.2 100c/c		0.170	0.168	0.165	0.162	0.164	0.167	0.165	0.151	0.110	0.130	0.110	0.150	0.170	0.168

*The additive contents are expressed as weight percentages based on the total weight of the compos

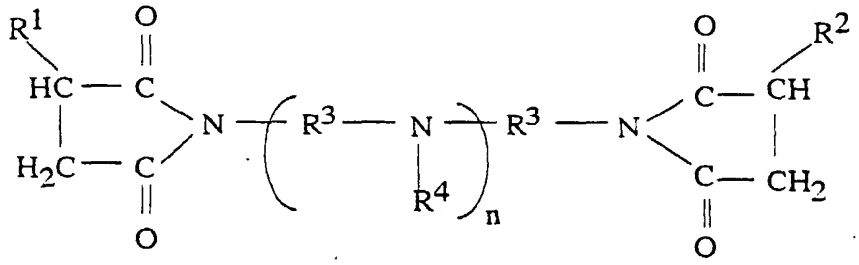
Industrial Applicability

The lubricating oil composition for an automatic transmission of the present invention is obtained by incorporating the above imide compound in a lubricating base oil. It is thereby possible to improve the slope of the μ-V curve, which is an index of the anti-shudder property in an automatic transmission fitted with a continuously slipping torque converter clutch. The lubricating oil composition thus exhibits excellent anti-shudder property without any loss in transmission torque capacity even when the lock-up mechanism is operated at low speeds, making it extremely useful as a drive transmission fluid.

According to the present invention, a method for lubricating an automatic transmission fitted with a continuously slipping torque converter clutch using said automatic transmission lubricating oil composition containing an imide compound can be provided. Furthermore, according to the present invention, an automatic transmission equipped with a lock-up clutch and filled with a lubricating oil composition having high transmission torque capacity and excellent anti-shudder property can be provided.

Claims

1. A lubricating oil composition for an automatic transmission comprising a lubricating base oil and an effective amount of a compound represented by the following general formula (I)



(I)

(wherein in general formula (I), R^1 and R^2 may be identical or different from each other and are each hydrocarbon groups having 5 or more carbons; R^3 is a divalent hydrocarbon group having 1 to 5 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 20 carbons; and n is an integer in the range of 0 to 10).

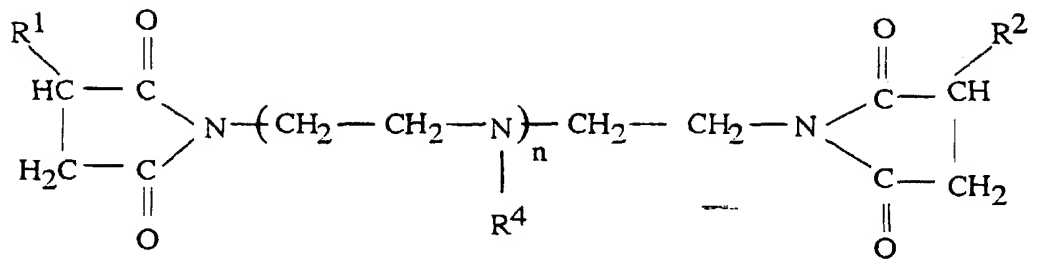
2. The lubricating oil composition for an automatic transmission according to claim 1 wherein the effective amount of the compound of general formula (I) is 0.02% by weight to 4% by weight based on the total weight of the lubricating oil composition.

3. The lubricating oil composition for an automatic transmission according to claim 1, wherein R^1 and R^2 in general formula (I) are each hydrocarbon groups having 5 to 40 carbons.

4. The lubricating oil composition for an automatic transmission according to claim 1 wherein R^1 and R^2 in general formula (I) are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons, and R^3 in general formula (I) is a divalent hydrocarbon group having 2 to 5 carbons.

5. The lubricating oil composition for an automatic transmission according to claim 1 wherein R^4 in general formula (I) is a hydrocarbon group which may include an amino group and/or an amide bond.

6. The lubricating oil composition for an automatic transmission according to claim 1 wherein the compound represented by general formula (I) is an imide compound represented by the following general formula (II)



(II)

(wherein in general formula (II), R^1 and R^2 may be identical or different, and are each unbranched straight-chain hydrocarbon groups having 8 to 25 carbons; R^4 is a hydrogen atom or a hydrocarbon group having 1 to 10 carbons, wherein said hydrocarbon group may include an amino group and/or an amide bond; and n is an integer of 1 to 5).

7. The lubricating oil composition for an automatic transmission according to claim 1 which in addition to said lubricating base oil, and (a) a compound represented by general formula (I), further comprises (b) 0.02% by weight to 5% by weight of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates, based on the total weight of the lubricating oil composition.

8. The lubricating oil composition for an automatic transmission according to claim 1 which in addition to said lubricating base oil, and (a) a compound represented by general formula (I), further comprises (b) 0.02% by weight to 5% by weight of at least one metal salt of an organic acid selected from the group consisting of sulfonates, phenates, salicylates and phosphonates: and (c) 0.01% by weight to 5% by weight of at least one compound selected from the group consisting of phosphate esters, acid phosphate esters, phosphite esters and acid phosphite esters, based on the total weight of the lubricating oil composition.

9. The lubricating oil composition for an automatic transmission according to claim 1 which in addition to said lubricating base oil, a compound represented by said general formula (I), and said metal salt of an organic acid and/or phosphorous compound, further comprises at least one type of additive selected from the group consisting of antiwear additives, viscosity index improvers, ashless dispersants, antioxidants, metal deactivators, corrosion inhibitors, defoamants and other additives required for automatic transmission lubricating oil compositions.

10. A method of lubricating an automatic transmission using the lubricating oil composition for an automatic transmission of claim 1.

11. An automatic transmission filled with the lubricating oil composition for an automatic transmission of claim 1.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/02025

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl^6 C10M133/16, 133/56, C10N40:04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl^6 C10M133/16, 133/56, C10N40:04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP, 6-271883, A (Honda Motor Co., Ltd.), September 27, 1994 (27. 09. 94) (Family: none)	1 - 11 1 - 11
Y	JP, 3-502114, A (Exxon Chemical Patents Inc.), May 16, 1991 (16. 05. 91), Claims 1, 4 & WO, 90/04625, A2 & EP, 394422, A & US, 5395539, A & US, 5484543, A	1 - 11

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
September 4, 1997 (04. 09. 97)	September 17, 1997 (17. 09. 97)
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